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SILVER YIELD FROM COPPER ORES AND THE EFFECTS OF 64.64-CENT SILVER ON THE VALUE OF COPPER ORES PRODUCED IN THE UNITED STATES

BY

ELMER W. PEHRSON

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SILVER YIELD FROM COPPER ORES AND THE EFFECTS OF 64.64 CENT SILVER ON THE VALUE OF COPPER ORES PRODUCED IN THE UNITED STATES[1]

By Elmer W. Pehrson[2]

CONTENTS

	Page
Introduction	1
Statistical summary	1
Silver yield per pound of copper produced from copper ores	3
Trends in copper, silver, and gold yield from copper ores	3
Relation of silver revenue to total revenue from copper ores	4
Relation of silver revenue to profits in copper mining	6
Effects of 64.64-cent silver on value of copper ores in recent years	7
Effects of 64.64-cent silver on total value and silver revenue from copper ores mined in principal producing regions of the United States	9
Conclusions	13

INTRODUCTION

The recent establishment of an official price of 64.64 cents per ounce for silver by the President's order of December 21, 1933, has provoked discussion as to the effects of this move on the various metal-mining industries. To assist those of the mineral industry who are interested in this problem, the Bureau of Mines presents the following analysis of basic statistical data concerning the relation of the silver price to the value of copper ores mined in the United States.

The term "copper ore" as used herein includes all ores in which copper is the most abundant base metal paid for. In 1928, this class of ore contributed 98 percent of the total copper output of the United States.

STATISTICAL SUMMARY

1. From 1907 to 1932 the average silver yield per pound of copper

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produced from copper ores ranged from a high of 0.01058 ounce in 1909 to a low of 0.00839 ounce in 1928. The value of this silver ranged from 1.21 cents per pound in 1919 to 0.25 cent in 1932.

2. A 64.64-cent silver price would have increased the average silver revenue per pound of copper as follows:

1928 - from 0.49 to 0.54 cent or 0.3 percent of the average copper price
1929 - from .49 to .63 cent or .6 percent of the average copper price
1930 - from .39 to .65 cent or 2.0 percent of the average copper price
1931 - from .27 to .61 cent or 3.7 percent of the average copper price
1932 - from .25 to .53 cent or 5.2 percent of the average copper price

3. The silver yield from copper ores declined 66 percent, from 1907 to 1928, whereas the copper yield declined only 33 percent.

4. The silver revenue per ton of copper ore declined from 46 cents in 1907 to 8 cents in 1931.

5. The silver revenue amounted to a maximum of 7.5 percent of the total revenue from copper ores in 1922 and a minimum of 2.7 percent in 1929.

6. The silver revenue per pound of copper in 1928 amounted to only 3 percent of the average selling price of copper but was equivalent to 11 percent of the average profit computed without allowance for depletion.

7. The 64.64-cent silver price will benefit the producer of nonporphyry copper in the West more than the producer of porphyry copper. Had this price prevailed in 1931 the silver yields would have been 1.47 cents per pound of nonporphyry copper and 0.12 cent per pound of porphyry copper, an advantage of 1.35 cents per pound in favor of the producer of nonporphyry copper.

8. A 64.64-cent silver price in 1932 would have increased the average recoverable value of all copper ores from $2.61 to $2.73 per ton, an increase of 12 cents per ton or 4.6 percent.

9. In 1932, the year in which the average price of silver was the lowest on record, the maximum increase that would have been effected by a 64.64-cent silver price in any of the 24 principal copper-producing districts of the United States was $1.24 per ton; in 11 districts, producing 61.8 percent of the total copper, the increase would have been only 5 cents or less per ton; and only in 5 districts, contributing 31.8 percent of the copper, would the increase in value have amounted to 50 cents or more per ton of ore mined.

10. The Butte, Verde (Jerome), Bisbee, Bingham, and Pioneer (Superior, Ariz.) districts alone accounted for 82.4 percent of the total silver derived from copper ores in 1928.

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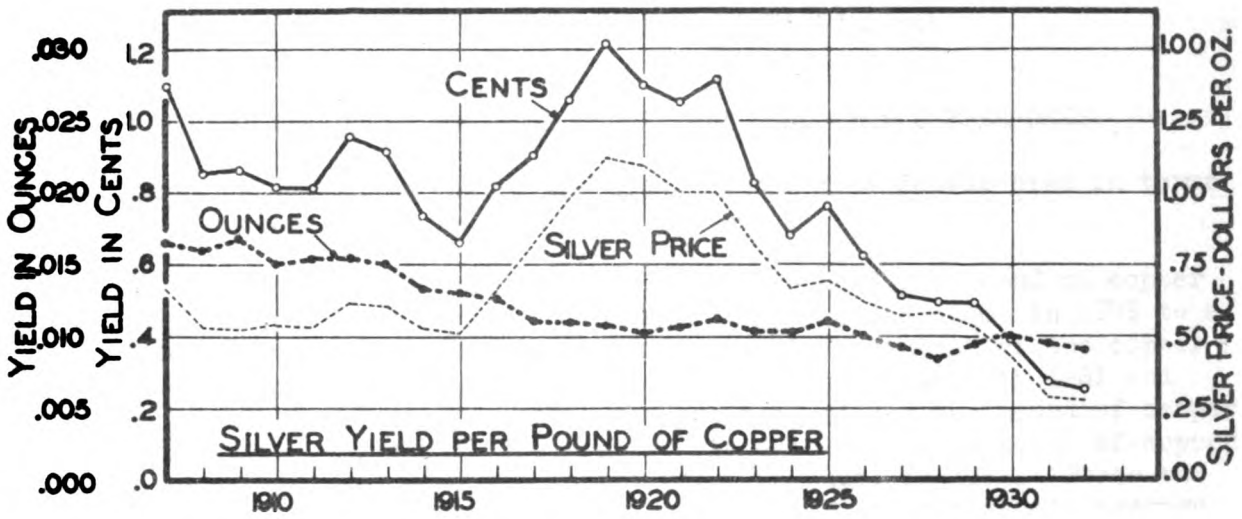

Figure 1.— Silver yield (in ounces and cents) per pound of copper produced from copper ores mined in the United States and the average yearly silver price, 1907-32.

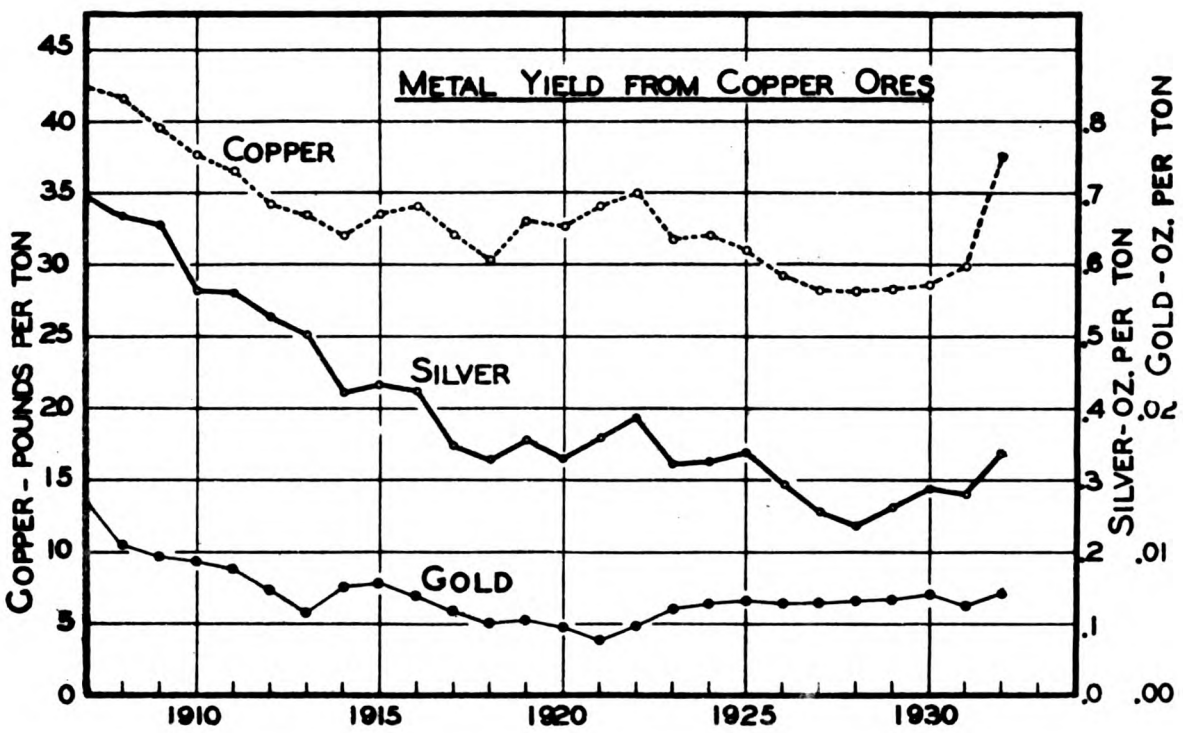

Figure 2.— Yield of copper, silver, and gold per ton of copper ore mined in the United States, 1907-32.

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11. In 1928 only 6 of the 24 principal copper-producing districts produced copper ores from which the silver yield would have been 1 cent or more per pound of copper, had silver been valued at 64.64 cents.

SILVER YIELD PER POUND OF COPPER PRODUCED FROM COPPER ORES

Figure 1 shows the trend in the silver yield from copper ores in terms of ounces and cents per pound of copper produced.

From 1907 to 1932 the quantity of silver produced per pound of copper has trended persistently downward from a high of 0.01658 ounce in 1909 to a low of 0.00839 ounce in 1928. Since 1928 the silver content of the copper ores mined has increased; but the increase in copper content in 1931 and 1932 was relatively greater, so that the yield of silver per pound of copper declined in those two years. The highest yield in value per pound of copper was 1.21 cents, in 1919; and the lowest was 0.25 cent, in 1932. These extremes coincided, respectively, with the highest and lowest yearly average prices of silver. Had silver been valued at 64.64 cents in recent years instead of under 40 cents the silver yields would have been increased from 0.39 to 0.65 cent in 1930, from 0.27 to 0.61 cent in 1931, and from 0.25 to 0.58 cent in 1932.

TRENDS IN COPPER, SILVER AND GOLD YIELD FROM COPPER ORES

Official figures showing the quantity of copper ore produced in the United States and the amount of copper, silver, and gold recovered therefrom have been reported from 1907 to 1931. These data, with estimates for 1932, are shown graphically in figure 2.

The chart shows a rather persistent downward trend in the copper and silver yield from copper ores up to 1929 and an upward trend thereafter. The gold yield declined steadily until 1921; since then it has trended upward.

The sharp decline in the copper yield from 1907 to 1914 may be ascribed primarily to the rapid increase in production from the low-grade porphyry deposits. In 1907, porphyry copper constituted only 6 percent of the total domestic output, but by 1914 the proportion had increased to 32 percent. Simultaneously, the copper yield decreased from 42 to 32 pounds per ton of ore. In succeeding years the rate of increase in the proportion of porphyry copper has been less pronounced. In 1928 it reached a peak of nearly 50 percent of the total output. That year also witnessed the lowest copper yield on record--28.17 pounds per ton. Were data available on the gross copper content of copper ores, a decline from 1914 to 1928 equivalent to that before 1914 probably would be evident, due to the continued increase in porphyry production and the general decline in the grade of ores mined. This has not been reflected in the yield, however, as the improvement in technology since 1914, principally through the introduction and perfection of the flotation process, has increased greatly the recovery of copper from ores.

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Under the stress of low prices in the more recent years the copper yield has increased, particularly in 1932, when it was estimated at 37.5 pounds per ton. The large increase in 1932 followed a sharp decline in the production of porphyry copper (to less than 40 percent of the total output) and a marked increase in the grade of ores mined at Butte, Bisbee, Magma, Jerome and the Lake Superior district. Some of the porphyries also produced higher-grade ores in 1932. Total copper production in 1932, however, was only 24 percent of the 1929 output, from which it may be concluded that with an increased demand for copper the grade of ore as mined in 1932 could not be maintained for any prolonged period.

Silver yield has declined even more than copper yield. From 1907 to 1928 the silver yield fell from 0.696 to 0.236 ounce per ton of ore, a decrease of 66 percent compared with a 33-percent drop in the copper yield. The greater decline in silver yield was due largely to the steady increase in production of porphyry ores which, compared with ores from other types of deposits, contain relatively much less silver than copper. Another contributing factor has been the declining silver content of some nonporphyry ores as the depth of mining increased.

The yield of gold from copper ores declined from 1907 to 1921, due to the same factors that affected the silver yield. The difference in the gold content of porphyry and nonporphyry ores, however, is much less than for silver, indicating that the declining gold content of nonporphyry ores was a more significant factor than the increased production of porphyry ores in the decreased gold yield. This is substantiated by the fact that from 1907 to 1920 the gold yield from copper ores decreased from 0.008 to 0.005 ounce per ton at Butte and from 0.087 to 0.025 ounce at Jerome. The seemingly paradoxical rise in the gold content of copper ores since 1921 may be attributed to the improved tenor of gold ores in the Butte and Jerome districts due to renewed activity in the upper levels and to increased production from the Magma mine, where the gold tenor of the ore is relatively high.

RELATION OF SILVER REVENUE TO TOTAL REVENUE FROM COPPER ORES

By applying average metal prices to the yields as shown in figure 1 the average yearly recoverable value per ton of copper ores is determined. These data, with the yearly average prices for copper and silver, are shown in table 1.

The highest per-ton value of copper ores from 1907 to 1932 was $9.18 in 1907, when copper averaged 20 cents per pound. In 1917 it rose to $9.12 under an average copper price of 27.5 cents, but declined to an estimated low of $2.61 in 1932. In 1929, when copper averaged 17.6 cents per pound, copper ores were valued at $5.26 per ton. Of the total value of copper ores, silver contributed a maximum of over 7.5 percent in 1922, with $1.00 silver, and a minimum of under 2.7 percent in 1929, with $0.53 silver. In terms of value, the silver yield has fluctuated from a high of $0.46 per ton in 1907 to a low of $0.08 in 1931. Revenue from gold has

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TABLE 1. - Metal yield and value of copper ores mined in the United States, 1907 to 1932

Year	Metal yield per ton of ore			Value per ton				Percent of total value		Average prices[2]	
	Copper, pounds	Silver, ounce	Gold, ounce	Total[1]	Copper	Silver	Gold	Silver	Gold	Copper	Silver
1907	42.2	0.696	0.0136	$9.18	$8.44	$0.46	$0.28	5.0	3.1	$0.200	$0.66
1908	41.6	.666	.0104	6.05	5.49	.35	.21	5.8	3.5	.132	.53
1909	39.5	.655	.0098	5.68	5.14	.34	.20	6.0	3.5	.130	.52
1910	37.6	.563	.0093	5.27	4.78	.30	.19	5.7	3.6	.127	.54
1911	36.5	.559	.0088	5.04	4.56	.30	.18	6.0	3.5	.125	.53
1912	34.1	.526	.0073	6.10	5.63	.32	.15	5.2	2.5	.165	.615
1913	33.4	.502	.0057	5.60	5.18	.30	.12	5.4	2.1	.155	.604
1914	32.0	.421	.0075	4.65	4.26	.23	.16	5.0	3.4	.133	.553
1915	33.5	.433	.0079	6.24	5.86	.22	.16	3.5	2.6	.175	.507
1916	34.0	.424	.0069	8.78	8.36	.28	.14	3.2	1.6	.246	.658
1917	31.9	.347	.0058	9.12	8.71	.29	.12	3.2	1.3	.273	.824
1918	30.2	.328	.0050	7.88	7.46	.32	.10	4.1	1.2	.247	.98
1919	33.0	.356	.0052	6.65	6.14	.40	.11	6.0	1.7	.186	1.12
1920	32.7	.330	.0047	6.48	6.02	.36	.10	5.6	1.5	.184	1.09
1921	34.0	.357	.0039	4.83	4.39	.36	.08	7.5	1.6	.129	1.00
1922	34.8	.386	.0049	5.19	4.70	.39	.10	7.5	1.9	.135	1.00
1923	31.6	.321	.0060	5.04	4.65	.26	.13	5.1	2.6	.147	.82
1924	31.8	.325	.0063	4.52	4.17	.22	.13	4.8	2.9	.131	.67
1925	30.8	.337	.0065	4.74	4.37	.23	.14	4.9	2.9	.142	.694
1926	29.3	.293	.0064	4.41	4.10	.18	.13	4.1	2.9	.140	.624
1927	28.2	.255	.0065	3.97	3.69	.15	.13	3.8	3.3	.131	.567
1928	28.2	.236	.0066	4.34	4.06	.14	.14	3.2	3.2	.144	.585
1929	28.3	.262	.0067	5.26	4.98	.14	.14	2.7	2.7	.176	.533
1930	28.6	.287	.0070	3.98	3.72	.11	.15	2.8	3.8	.130	.385
1931	29.9	.281	.0063	2.93	2.72	.08	.13	2.7	4.4	.091	.290
1932	37.5[3]	.338[3]	.0071[3]	2.61	2.36	.10	.15	3.8	5.8	.063	.282

1 Does not include revenue from small amounts of lead, zinc, and other byproducts derived from copper ores.
2 As reported by the Bureau of Mines.
3 Rough estimate.

1736

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ranged from $0.08 per ton in 1921 to $0.28 in 1907 and from 1.2 percent of the total value of the ore in 1918 to 5.8 percent in 1932. The combined revenue from gold and silver never has exceeded 10 percent of the total value of copper ores in any year from 1907 to 1932 and amounted to only 4.5 percent in 1917.

. . . . . .

The above figures apply to the average of all copper ores mined in the United States. In individual mines the importance of silver revenue varies considerable, but Merrill[3] has shown that less than 2 percent of the copper produced in the United States in 1928 came from mines in which silver contributed over 10 percent of the total revenue derived from the ores. His study, which was based on an analysis of individual mines, showed that 88.5 percent of the copper was derived from ores in which silver contributed 0 to 10 percent of the total value, 1.1 percent from ores in which silver contributed 10 to 20 percent of the value, 0.6 percent from 20- to 30-percent ores, and 0.1 percent from 30- to 40-percent ores; 9.9 percent was derived from ores free of silver or unclassified as to silver content, but virtually all of this copper was produced from the silver-free ores of the Lake Superior district. Thus, in 1928, over 98 percent of the copper was derived from ores in which silver contributed less than 10 percent of the total revenue.

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RELATION OF SILVER REVENUE TO PROFITS IN COPPER MINING

The average money yield from silver per pound of copper produced from copper ores has ranged from 2.8 to 8.2 percent of the average selling price of copper; in recent years it has been 3 to 4 percent. These percentages seem small in relation to normal fluctuations of the copper price, but viewed from the standpoint of profits have considerably greater significance. In 1928 the average silver revenue was equivalent to only percent of the average selling price of copper but to about 11 percent of the estimated average profit computed without allowance for depletion.

Revenue derived from silver is largely "velvet" to the copper miner, for this reason: Silver (and gold, too) follows the copper through the various stages of mining, milling, and smelting and finally is contained in the blister copper at virtually no additional expense over that required for the recovery of the copper alone. Usually the blister requires electrolytic refining before it can be marketed so that, as a practical proposition, the only expense entailed in marketing byproduct silver is that involved in recovering it from the refining sludge and the selling charges. These are relatively small compared with the selling price so that, broadly speaking, production of byproduct silver from copper ores is profitable and augments the profits from copper mining to a considerable degree. Moreover,

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3 Merrill, Charles White, Economic Relations of Silver to Other Metals in Argentiferous Ores: Economic Paper 10, Bureau of Mines, 1930 table 19, p. 20.

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a large part of this profit accrues to the miner, as in ores containing appreciable amounts of silver the smelter usually pays for 95 percent of the silver content at 1/2 to 1 cent under the market price.

An approximate idea of the relation of silver revenue to profits from copper mining can be obtained from the report[4] of the Tariff Commission on the cost of producing domestic copper. According to this report the average cost in 1928, including depreciation but excluding depletion, was 9.22 cents per pound, to which should be added interest charges of 1.17 cents, making a total average cost of 10.39 cents. This includes a credit of 0.90 cent for revenue derived from the sale of byproducts, of which silver accounted for about 0.45 cent. Since the average selling price of copper as reported by the Bureau of Mines was 14.40 cents in 1928, an average profit of 4.01 cents per pound is indicated. The silver yield of 0.45 cent, therefore, was equivalent to 11 percent of the average profit before deductions for depletion.

EFFECTS OF 64.64-CENT SILVER ON VALUE OF COPPER ORES IN RECENT YEARS

Most of the byproduct silver from copper ores is produced in the Western States[5]. In 1931 this area produced 86 percent of the copper and over 99 percent of the silver derived from copper ores; the Central and Eastern States contributed 14 percent of the copper and less than 1 percent of the silver. For this reason any benefits to be derived from increased silver revenue will accrue to the Western States.

Table 2 shows the value per ton of all copper ores mined in the United States and in the Western States from 1926 to 1932 and the effects of 64.64-cent silver on these values; the effects on silver revenue per pound of copper also are shown.

The table shows that 64.64-cent silver in 1932 would have increased the total revenue of all copper producers in the United States an average of 4.6 percent and that of producers in the Western States 5.1 percent. In terms of silver revenue per pound of copper the average for the nation as a whole in 1932 would have been increased from 0.25 to 0.58 cent, while that in the Western States would have increased from 0.29 to 0.67 cent per pound. These increases in revenue due to the higher silver price were equivalent to 5.2 and 6.0 percent of the average selling price of copper, respectively.

Higher prices for silver will benefit the producer of vein or nonporphyry copper more than the producer of porphyry copper. In 1931, when silver averaged 29 cents an ounce, the silver yield from nonporphyry mines in the West was 0.66 cent per pound of copper compared with 0.05 cent for

4 United States Tariff Commission, Report to the United States Senate on Copper: Rep. 29, 2 ser., 1932, pp. 7 and 34.

5 Alaska included in Western States.

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TABLE 2. - Increases in value of copper ores mined in the United States, 1926 to 1932, had silver been valued at 64.64 cents an ounce.

	Average total value per ton of ore mined				Silver revenue per pound of copper			
	Actual	Silver reckoned @ 64.64¢			Actual	Silver reckoned @ 64.64¢		
		Total value	Increase over actual			Amount	Increase	
			Amount	Percent			Amount	Percent of average copper price
United States	Dollars	Dollars	Dollars		Cent	Cent	Cent	
1926	4.41	4.42	0.01	0.2	0.62	0.65	0.03	0.2
1927	3.97	3.98	.01	.3	.51	.59	.08	.6
1928	4.34	4.35	.01	.2	.49	.54	.05	.3
1929	5.26	5.29	.03	.6	.49	.60	.11	.6
1930	3.98	4.06	.08	2.0	.39	.65	.26	2.0
1931	2.93	3.03	.10	3.4	.27	.61	.34	3.7
1932[1]	2.61	2.73	.12	4.6	.25	.58	.33	5.2
Western States								
1926	4.59	4.60	.01	.2	.70	.72	.02	.1
1927	4.15	4.17	.02	.5	.58	.66	.08	.6
1928	4.45	4.46	.01	.2	.55	.61	.06	.4
1929	5.37	5.40	.03	.6	.55	.67	.12	.7
1930	4.06	4.15	.09	2.2	.45	.76	.31	2.4
1931	2.91	3.03	.12	4.1	.31	.70	.39	4.3
1932[1]	2.57	2.70	.13	5.1	.29	.67	.38	6.0

1 Rough estimates.

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porphyry copper; with 64.64-cent silver the yields would have been 1.47 cents and 0.12 cent, respectively, an advantage of 1.35 cents per pound in favor of vein copper.

EFFECTS OF 64.64-CENT SILVER ON TOTAL VALUE AND SILVER REVENUE FROM COPPER ORES MINED IN PRINCIPAL PRODUCING REGIONS OF THE UNITED STATES

In table 3 the effects of 64.64-cent silver on the total value per ton of copper ores mined in the principal producing districts under various metal prices are shown. Average prices for 1928, 1932, and November 1933 were selected as representing, respectively, predepression normal prices, the lowest yearly averages on record, and the situation before the new silver price was declared. The grade of ore as mined in 1928 was used as a basis for comparison, as it was thought that such ore more nearly approximated the average grade of reserves in the various districts than would that mined under the high metal prices of 1929 and the low prices thereafter. The data have been derived from Mineral Resources of the United States, 1928, and published company reports.

The copper production of the 24 districts listed above accounted for 98 percent of the total output in 1928. The silver yield per ton of ore ranged from a low of 0.002 ounce in the Lake Superior district to a high of 3.418 ounces in the Pioneer (Superior) district of Arizona. With silver valued at 64.64 cents per ounce these yields were equivalent to less than ½ cent and $2.21 per ton, respectively. Of the districts shown, 10, representing 58.1 percent of the total 1928 copper production, produced ores in which the average silver yield was 0.1 ounce per ton or less; 8, with yields ranging from 0.1 to 1.0 ounce per ton, produced 7.8 percent of the total; and 6, with yields of over 1.00 ounce per ton, contributed 32.1 percent of the total. These groups produced 13.9, 5.8 and 75.3 percent, respectively, of the total silver derived from copper ores in 1928.

The new silver price would have had slight effect on the value of copper ores in 1928, the maximum increase being $0.20 per ton; in 8 districts the increase would have been less than one half cent per ton. In 1932, owing to the extremely low silver price, the maximum increase effected by 64.64-cent silver would have been $1.24 per ton, but in 11 districts producing 61.8 percent of the total copper the increase would have been only 5 cents or less per ton. Only in 5 districts, contributing 31.8 percent of the copper, would the increase in value have amounted to 50 cents or more per ton of ore mined.

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TABLE 3. - Metal yield per ton of copper ore produced in the principal districts in 1928, its average value per ton under average metal prices of 1928, 1932 and November 1933, and the increase in value that would have resulted from 64.64-cent silver

District		Percent of 1928 total copper output	Metal yield per ton of ore: Copper	Silver		Gold	Actual value 1/ per ton under average metal prices of			Increase in value per ton 64.64-cent silver would have effected		
				Ounces	Value @ 64.64¢		1928	1932	Nov. 1933	1928	1932	Nov. 1933
			pounds			ounces						
Bingham	Utah	15.9	16.99	0.073	$0.05	0.0007	$ 2.63	$ 1.23	$ 1.59	$0.01	$0.03	$0.02
Butte	Mont.	13.7	77.89	1.806	1.17	.0078	12.44	5.58	7.19	.10	.65	.38
Lake Superior	Mich.	9.9	24.24	.002	.00	---	3.49	1.53	1.91	.00	.00	.00
Verde (Jerome) 2/	Ariz.	9.1	88.44	1.373	.89	.0353	14.27	6.69	8.76	.09	.50	.30
Bisbee porphyry	do.	3.7	46.82	.133	.09	.0057	6.94	3.11	3.95	.01	.05	.03
Nonporphyry	do.	5.2	91.73	1.734	1.12	.0534	15.32	7.37	9.78	.11	.63	.37
Ely 2/	Nev.	7.8	24.78	.039	.03	.0119	3.84	1.82	2.38	.00	.01	.00
Miami	Ariz.	7.5	14.92	.007	.00	.0001	2.15	.94	1.18	.00	.00	.00
Chino	N. Mex.	4.4	22.31	.021	.01	.0015	3.25	1.45	1.82	.00	.00	.00
Ajo	Ariz.	4.3	21.59	.047	.03	.0045	3.20	1.45	1.86	.00	.02	.01
Ray	do.	3.8	21.17	.021	.01	.0003	3.07	1.35	1.69	.00	.00	.00
Morenci 2/	do.	3.0	34.09	.085	.05	.0038	5.04	2.25	2.86	.00	.03	.01
Pioneer (Superior)	do.	2.0	138.99	3.418	2.21	.0297	22.62	10.33	13.44	.20	1.24	.73
Copper River	Alaska	1.8	223.87	1.873	1.21	---	33.34	14.63	18.50	.11	.68	.40
Globe	Ariz.	1.3	54.02	.326	.21	.0104	8.13	3.70	4.76	.02	.12	.07
Plumas County	Calif.	1.2	28.23	.436	.28	.0197	4.74	2.31	3.08	.02	.16	.09
Ducktown	Tenn.	.9	21.55	.099	.06	.0007	3.17	1.40	1.76	.00	.03	.02
Yerington 2/	Nev.	.6	22.13	.024	.02	---	3.20	1.40	1.76	.01	.01	.01
Prince Wm. Scund	Alaska	.5	20.36	.185	.12	---	3.04	1.33	1.69	.01	.07	.04
Swain County	N. C.	.5	111.92	.260	.17	.0012	16.30	7.15	8.99	.02	.10	.06
Lordsburg 2/	N. Mex.	.3	50.94	1.090	.70	.1160	10.38	5.92	8.36	.06	.39	.23
Battle Mtn. 2/	Nev.	.2	254.52	.372	.24	.0071	37.02	16.28	20.51	.02	.14	.08
Shasta County	Calif.	.2	22.76	.497	.32	.0072	3.72	1.72	2.25	.03	.18	.11
Silver Bell	Ariz.	.2	75.69	.260	.17	---	11.05	4.84	6.09	.02	.10	.06

1/ Value of miscellaneous byproducts, such as sulphuric acid, lead, etc., not included.
Average prices taken as follows:

	Gold	Silver	Copper
1928	$20.67+	58.5¢	14.4¢
1932	20.67+	28.2	6.3
Nov. 1933	33.34	43.0	7.9

2/ County data shown. District data not available.

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Table 4 shows the silver yield and total revenue per pound of copper in the principal copper-producing districts in 1928 and the increase in revenue that would have been effected by 64.64-cent silver in recent years.

The 24 districts shown accounted for 95 percent of the total silver produced from copper ores in 1928. The Butte, Verde (Jerome), Bisbee, Bingham, and Pioneer (Superior) districts alone yielded 82.4 percent of the total, though these same districts produced less than half of the copper output in 1928.

Seven districts, which produced ores with an average silver yield of 0.1 cent per pound of copper or less (silver valued at 64.64 cents), contributed only 3.2 percent of the silver and 34.2 percent of the copper; 8 with yields ranging from 0.11 to 0.50 cent produced 29.8 percent of the copper and 13.2 percent of the silver; 4 with yields of 0.51 to 1.00 cent, 12.6 percent of the copper and 22.0 percent of the silver; and 5 with yields in excess of 1 cent per pound 21.4 percent of the copper and 56.6 percent of the silver.

In 1928, when silver averaged 58.5 cents per ounce, the maximum increase in revenue in any district that would have resulted from a 64.64-cent silver price was less than 1 percent of the actual revenue received in that year; in 1932, the maximum increase would have been 12.1 percent; and in November 1933, 5.5 percent. In 1932, 3 districts which produced 15.9 percent of the 1928 copper output would have enjoyed increases of 10 percent or more in revenue; 5, yielding 16.3 percent of the copper output, would have had increases from 5 to 10 percent; 4, producing 19.9 percent of the copper, increases from 2 to 5 percent; and 12, contributing 45.9 percent of the copper, increases under 2 percent.

The contrast in the increase in revenue resulting from the higher price for silver between porphyry and nonporphyry districts is striking. In 1932, the 8 porphyry districts would have enjoyed an average increase in money yield of only 1.2 percent, whereas the 8 principal nonporphyry districts, exclusive of Lake Superior, where the silver yield is negligible, would have had an average increase of 9.1 percent. The 8 porphyry districts contributed 50.4 percent of the total copper output in 1928, whereas the 8 nonporphyry districts contributed 33.2 percent.

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TABLE 4. - Silver yield and total revenue per pound of copper produced from copper ores in the principal producing districts of the United States and the increase in revenue that would have been effected by 64.64-cent silver in 1928, 1932, and November 1933

District		Percent of total silver produced from copper ores, 1928	Silver yield per pound of copper		Total revenue per pound of copper under average prices of			Increase in total revenue 64.64-¢ silver would have effected					
								1928		1932		Nov. 1933	
			Ounce	Value @ 64.64¢	1928	1932	Nov. 1933	Amount	Percent	Amount	Percent	Amount	Percent
								cent		cent		cent	
Butte	Mont.	38.6	0.0232	1.50¢	15.97¢	7.16¢	9.23¢	0.14	0.9	0.85	11.9	0.50	5.4
Verde (Jerome)	Ariz.	17.5	.0155	1.00	16.14	7.56	9.91	.10	.6	.56	7.4	.34	3.4
Bisbee	do.												
Porphyry		1.3	.0028	.18	14.82	6.64	8.44	.02	.1	.10	1.5	.06	.7
Nonporphyry		10.7	.0189	1.22	16.70	8.03	10.66	.12	.7	.69	8.6	.41	3.8
Bingham	Utah	8.2	.0043	.28	15.48	7.24	9.36	.03	.2	.16	2.2	.09	1.0
Pioneer (Superior)	Ariz.	6.1	.0246	1.59	16.27	7.43	9.67	.15	.9	.90	12.1	.53	5.5
Plumas County	Calif.	2.2	.0154	.99	16.79	8.18	10.91	.09	.5	.56	6.8	.33	3.0
Copper River	Alaska	1.7	.0084	.54	14.89	6.54	8.26	.05	.3	.31	4.7	.18	2.2
Ely	Nev.	1.5	.0016	.10	15.50	7.34	9.60	.01	.1	.06	.8	.03	.3
Ajo	Ariz.	1.2	.0022	.14	14.96	6.78	8.70	.01	.1	.08	1.2	.05	.6
Globe	do.	.9	.0060	.39	15.14	6.85	8.81	.04	.3	.22	3.2	.13	1.5
Morenci	do.	.9	.0025	.16	14.78	6.60	8.39	.02	.1	.09	1.4	.05	.6
Lordsburg	N. Mex.	.7	.0214	1.38	20.38	11.62	16.41	.13	.6	.78	6.7	.46	2.8
Prince Wm. Sound	Alaska	.6	.0091	.59	14.93	6.53	8.30	.06	.4	.33	5.1	.20	2.4
Chino	N. Mex.	.5	.0009	.06	14.57	6.50	8.16	.01	.1	.03	.5	.02	.2
Ducktown	Tenn.	.5	.0046	.30	14.71	6.50	8.17	.03	.2	.17	2.6	.10	1.2
Ray	Ariz.	.5	.0010	.06	14.50	6.38	7.98	.01	.1	.04	.6	.02	.3
Shasta County	Calif.	.5	.0218	1.41	16.34	7.56	9.89	.13	.8	.79	10.4	.47	4.8
Miami	Ariz.	.4	.0005	.03	14.41	6.30	7.91	.00	.0	.02	.3	.01	.1
Swain County	N.C.	.1	.0023	.15	14.56	6.39	8.03	.01	.1	.08	1.3	.05	.6
Lake Superior	Mich.	.1	.0001	.01	14.40	6.30	7.90	.00	.0	.00	.0	.00	.0
Yerington	Nev.	.1	.0011	.07	14.46	6.33	7.95	.01	.1	.04	.6	.02	.3
Silver Bell	Ariz.	.1	.0034	.22	14.60	6.39	8.05	.02	.1	.12	1.9	.07	.9
Battle Mountain	Nev.	.1	.0015	.10	14.55	6.40	8.06	.01	.1	.05	.8	.03	.4

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CONCLUSIONS

Consideration of the magnitude of the changes effected in the value of copper ores by 64.64-cent silver leads to the conclusion that the new silver price will have little ultimate effect on the copper-mining industry of the United States. Assuming the return of a normal demand for copper supplied by domestic production, the following deductions seem warranted:

1. Copper production from the high-silver districts will not be stimulated by the new silver price to a point where stocks of copper will be increased further.

2. Production of byproduct silver from copper ores will not be increased greatly.

3. The geographical distribution of copper production in the United States will not be altered materially.

Stimulation of copper production, with resultant increase in copper stocks, probably would not occur if the production quotas specified in the proposed Copper Code are carried out. But even assuming that there were no control over production there seems to be no basis for concluding that the new silver price of itself would result in any substantial increase in copper production. Consider the situation in November 1933, just before the new silver price was established. During that month the average price of copper was 7.9 cents per pound and that of silver 43 cents an ounce. Had silver been valued at 64.64 cents an ounce the maximum additional revenue per pound of copper in any of the 24 principal producing districts would have been about 0.5 cent; in only eight districts, which in 1928 produced less than a third of the total copper, would it have amounted to 0.2 cent or more. Thus an increase of only 0.5 cent per pound in the price of copper would have accomplished the same increase in revenue, even in the districts with the highest silver yield, and an increase of 0.2 cent in copper price would more than offset the effects of 64.64 silver in districts producing two thirds of the copper. It is therefore apparent that the additional revenue created by the newly established silver price could be wiped out by a comparatively small drop in the price of copper. Under these circumstances it seems unreasonable to suppose that producers of copper ores of high silver content will adopt a policy of realizing larger revenue from silver by increasing production at the risk of again increasing copper stocks and upsetting the copper price. The absence of any outstanding relation in the past between the trends of silver price and average silver yield seems to indicate that selective mining of the higher silver ores in a given mine to increase silver production without adding to the copper surplus would not be feasible.

Higher silver prices may result in some increase in production of byproduct copper, but the amount available from this source is relatively small and should be insignificant under normal conditions. In 1928, total byproduct copper amounted to only 14,662 tons or less than 2 percent of the

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total output. That derived from gold and silver ores and the complex copper-lead-zinc ores is most apt to be effected by the silver price. These types of ores contributed only 4,384 and 2,175 tons of copper, respectively, in 1928

With regard to the possibility of increased production of silver from copper ores as a result of the higher price of silver, the best guide, perhaps, is past experience. From 1907 to 1928 the silver yield from copper ores trended downward persistently, notwithstanding great fluctuations in the price of silver. For instance, from 1915 to 1919 the price of silver rose from $0.51 to $1.12 an ounce, yet the silver yield decreased from 0.433 to 0.355 ounce per ton of ore. The failure of the silver yield to respond to the great increase in price during this period may have been due to the unusual stimulation of copper production to meet the war-time demand, which, in turn, may have prevented selective mining for silver. By 1919, however, this demand had subsided, and domestic production had decreased 37 percent. This relief from the pressure for copper production should have permitted selective mining for high-silver-bearing copper ores if such a practice had been possible. That there was sufficient incentive for increasing silver production from copper ores is indicated by the fact that the silver price in 1919 was 120 percent higher than in 1915, whereas the copper price was only 6 percent higher. Even this large increase in the importance of silver revenue failed to arrest the steady downward trend in the silver yield from copper ores. It may therefore be concluded that silver yield from copper ores does not vary with normal fluctuations in the price of silver but depends on the grade of ores available to supply the demand for copper at any given time.

One factor which might affect future production of silver from copper ores is the possibility of increased copper production and consequently increased silver production induced by the new silver price, in the districts with high silver yield. In any appraisal of the ultimate effects of 64.64-cent silver in this direction its relation to previous price levels should be considered. During the 10 years, 1907 to 1916, the price averaged 57.2 cents and from 1924 to 1929, 61.2 cents. The newly established price is so close to these averages that resultant changes of any importance in the copper industry are hardly conceivable unless the price of copper is to remain at present low levels. Since the present capacity for producing copper probably was calculated to operate profitably under an expectancy of approximately 14-cent copper and 60-cent silver, it may be argued that 64.64-cent silver and the present low price of copper (8 cents) have changed the silver-copper price ratio so radically that if they are continued indefinitely the balance of production between the various districts might be disturbed. It has been shown also that the new silver price is more advantageous to western than to eastern mines and provides more revenue to producers of vein copper than to producers of porphyry copper. Production may receive some stimulus in districts where the silver revenue constitutes a considerable proportion of the total value of the ores while consumption of copper is curtailed; but should consumption of copper return to normal price adjustments would be inevitable because the high-silver copper districts could not supply the demand.

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In 1938 the districts which produced 82 percent of the silver derived from copper ores produced less than half the copper. In the last analysis the deciding factor as to which districts will survive will be the net cost of producing copper; in determining this, the precious metal content of the ore is only one of many factors. Some of our lowest cost producers operate on low-grade ores in which the silver and gold content is relatively small. The new silver price, therefore, is not to be expected to cause much change in the sources of copper production in the United States--or greatly to increase the production of byproduct silver from copper ores.

In conclusion, it may be said that the role of 64.64-cent silver in the future of the United States copper industry will be very small indeed compared with such factors as the future trend of the price of copper, the future copper-tariff policy of the United States, and the future developments in copper technology.

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